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Modeling for Ship Design and Production

VIB-1

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Abbreviations

AMICE	ESPRIT Project 688 - Open System Architecture for CIM
CIM	Computer Integrated Manufacturing
ESPRIT	European Strategic Programme for Research and Development in Information Technology
GRAI	Groupe de Recherche en Automatisation Integriel
IDEF	I*CAM (Integrated Computer Aided Manufacturing) Definition Language
IMPPACT	hrtergated Modelling of Products and Processes using Advanced Computer Technology
IT	Information Technology
MARIN-ABC	Marine Industry Applications of Broadband Communication
MB/BB	Narrowband/Broadband
NEUTRABAS	Neutral Database for Complex Multifunctional Systems
NIDDESC	Navy Industry Digital Data Exchange Standardization Committee
NIAM	Nijssen Information Analysis Method
OoDB	Object oriented Database
OSA	Open System Architecture
RACE	Research and Development in Advanced Communication Technology in Europe
R&D	Research and Development
ROCOCO	Real Time Monitoring and Control of Construction Site Manufacturing
SQL	Structured Query Language
STEP	Standardization for the Exchange of Product Defining Data

ABSTRACT

The flexible operating and changing of the complex one-of-a-hind shipbuilding environment has to be based on adequate concepts and instruments to handle the related controlling, planning and implementation tasks. Product modeling defines the physical and application driven product related information. It is of basic importance to support this environment, especially the concurrent engineering functions, during the whole product life-cycle. Process modeling supports the implementation and operation of complex CIM (computer Integrated Manufacturing) oriented processes. In this paper some modeling applications within European shipbuilding R&D (research and development) projects will be highlighted from the view-point of an integrated product and process modeling approach. The following projects will be referenced:

- NEUTRABAS (Neutral Database for Complex Multifunctional Systems) explores a broad application field of product information for ship steel structure and outfitting systems;

- ROCOCO (Real Time Monitoring and Control of Construction Site Manufacturing) develops a CIM-application and demonstrates this application within the pipe outfitting environment of a ship berth construction site; and

- MARIN-ABC (Marine Industry Applications of Broadband Communication) demonstrates new applications and services in the maritime transportation business based on future mobile satellite networks.

INTRODUCTION

Information or system modeling of products and processes is becoming more and more important for planning, reconfiguration and operation of especially complex one-of-a-kind systems.

A model in the context of this paper gives an certain understanding of the real world in a descriptive form. Modeling is the task to

identify the universe of discourse;
abstract from the universe of discourse towards an "academical" interpretation; and
formalize the universe of discourse towards an unambiguous representation.

The universe of discourse within the real world is on one hand the product "ship" and on the other hand the process "ship roduction"(figure 1). The "ship" is defined as the physical product and the related information within the physical production process. The product has to be delivered within the chain of order processing. The process "ship production" is defined by the relevant order processing enterprize functions, the related tasks and physical production environment.

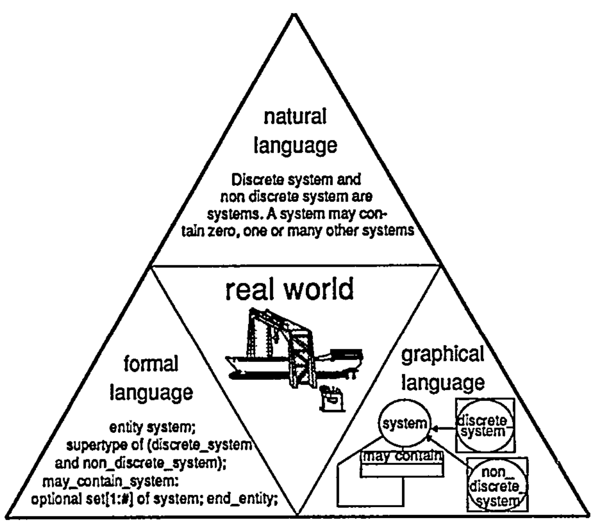


Figure 1: From Real World to Model

The product "ship" is described by information about its specific parts, systems and features. The information content of the model of the product "ship" is application driven. This means that the information needs of every application related to a task define the information content of the model.

The process "ship production" is described as a frozen dynamic (quasi static) system of activities. These activities within the production process are executed by applications. Many of these tasks can be IT-supported these are the ones faced at for the realization of CIM-concepts.

The universe of discourse in which the product and the production process are part of, is the life-cycle of ships in general. The life-cycle of the product "ship" is derived from the characteristics of process elements and the entities handled by the processes. The life-cycle builds the structured background for the modeling exercises presented in this paper. It starts with the sketching of the first idea and ends with the ship's operation or its final wreckage. From a bird's-eye view

- bid preparation,
- pre-design and design
- production coordination,
- production,
- operation, and
- (wreckage)

are the relevant steps within the life-cycle of ships.

The different reasons for a product model are derived from facts like support of information sharing, concurrent engineering, rapid calculations and development of alternatives. Starting from a first sketched idea of the future product, the amount of information for a product and its production increases steadily (figure 2). The ability to

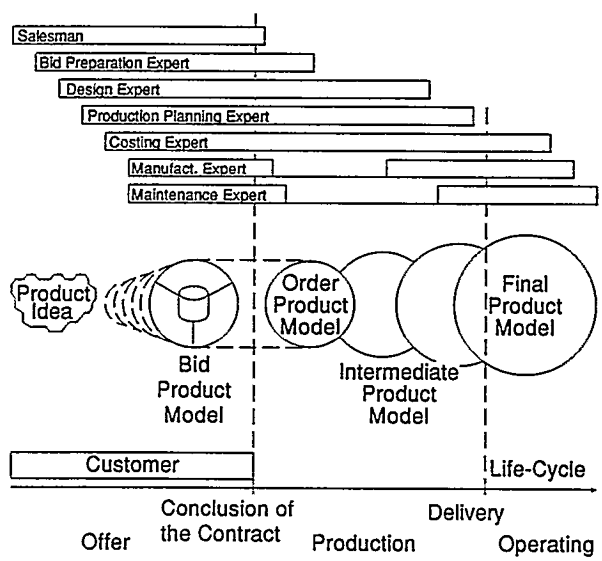


Figure 2: Evolution of Product Model

keep this information consistent and to support all related tasks in the development process with the correct data at the actual time, can be proved by a product model. A product model serves as a kernel to plug in all application programs and make use of the resulting synergy effects.

The development of a complex model as refered to in this paper is called product modeling. Maintaining the product model requires a sophisticated modeling technique to make changes and additions possible without redesigning the whole model and its related applications. The modeling methodology of the evolving standard STEP and its descriptive language EXPRESS is an approach able to fulfil the above mentioned requirement (1).

The necessity of process modeling approaches arises from the complexity and the flexibility requirements of the shipbuilding manufacturing process. The increasing degree of computer and communication technology support within industrial manufacturing environments in general leads to the need of a “structured concept or architecture” for CIM which is called “open system architecture” (2). The characteristic features of one-of-a-kind production - what shipbuilding obviously is - such as complexity and flexibility regarding the product and production, concurrent engineering constraints, and parallel manufacturing processes requires process models as an instrument of planning, reconfiguration and operation of the order processing and the corporate enterprize planning. In the context of this paper the tasks potentially supported by process modeling are:

- operation of complex CIM production systems;
- design, implementation, and adaption of CIM in production systems;
- cost-benefit analysis and techno-economic evaluation in the framework of plant layout (CIM-implementation); and
- marketability and risk assessment of future products and/or services to be provided.

MOTIVATION

The increasing complexity and individuality of products, especially focussed on capital goods, strengthens the importance of one-of-a-kind principles within the manufacturing industrial sector. Especially the European shipbuilding industry has foccussed their product range on specialized and technically complex vessels such as container ships, passenger and multi-purpose ferries, specialized freighters and research vessels.

The economical constraints combined with strong market requirements of shortest delivery times have heavily influenced the manufacturing concepts of European shipbuilders. The hierarchical and modular organization of shipbuilding processes is developing more towards complex and parallel automated CIM-processes (figure 3). Due to the relativly small size and specialization of the European shipbuilding industry, one-of-a-kind as well as concurrent engineering principles have characterized the manufacturing environment, even before computer support has influenced the overall ship building processes.

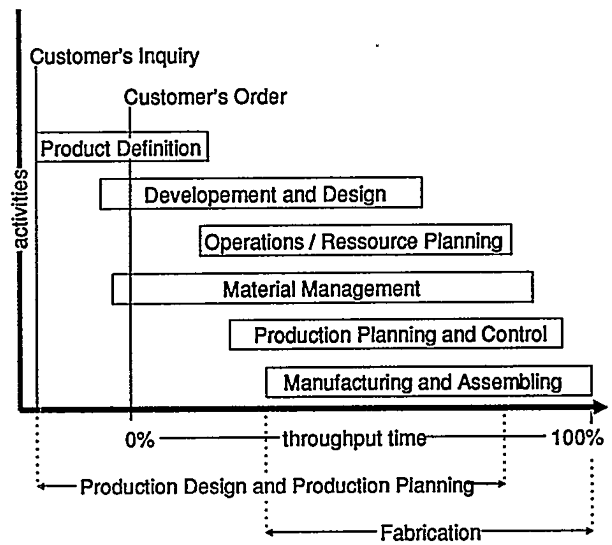


Figure 3:
Parallel Production Processes in Shipbuilding

Product complexity

High-tech (high-cost) carriers and specialized vessels - the characteristic product range of European shipbuilders - in general have complex, multifunctional product structures. Product complexity has following CIM-relevant impacts on engineering and production processes:

- sophisticated products demand multi-discipline engineering support;
- distributed knowledge and resources lead to distributed manufacturing concepts and a concurrent engineering approach; and
- design coordination as well as production coordination requires neutral product data exchange and product data sharing.

The inter-operability of functional ship systems such as steel structure, machinery, and electric is difficult to handle in daily business. If the interaction of system variables (e.g. engine performance versus vessel hydrodynamics) does not reach the planned result, a single person is almost unable to check all relations affected by such deviation. In this context distributed multifunctional design requires information structures and applied tools to follow and control all changes and inputs. Organizational functions during product design such as version control, approvals, and changes need to be based on the knowledge about the overall information flow within the engineering tasks. The need for knowledge about the 'where' and 'from' of the information makes the demand for an product of process model obvious.

Production complexity

The manufacturing of one-of-a-kind products such as ships is as a multidiscipline prefabrication and assembling process. Prefabrication, pre-assembly, pre-outfitting and outfitting work has to be scheduled and executed as parallel processes. Different kinds of resource organization (e.g. workshops, line-production, construction-site), different levels of automation (e.g. craftmanship, conventional tooling machines, NC- and DNC-machines) and different disciplines of qualification make up the ship production process. Quality control of distributed prefabrication steps and coordination of work such as assembly and outfitting have to be based on an overall information and control structure. Following aspects of ship production must be mentioned:

- automated and integrated production, especially for one-of-a-kind products requires high performance data handling;
- distributed manufacturing and just-in-time supply require adequate production planning and control concepts; and
- shorter delivery time demands a higher parallelism of all steps for production including concurrent quality control.

The requirements for implementing and adapting CIM-solutions to this one-of-a-kind production environments are in general anticipated in a broad field the manufacturing industry. From both the viewpoint of the IT users and the IT providing industry "generalized models are required to identify the principle components, processes, constraints and information sources to describe a manufacturing business processing towards CIM." (2)

Production flexibility

Due to the characteristics of European shipbuilders regarding of the product range, the value of flexibility regarding the production environment is of increasing importance. Changing product types, complexity and parallelism of order processing, short throughput times and fixed due dates lead to different aspects of flexibility reagrding the overall manufacturing process.

From the viewpoint of ship design, flexibility has to be understood as:

- developing design solutions depending on actual requested optimization criteria (costing, weight, noise, waste minimization, etc.) or any combination of those;
- developing different ship systems in parallel, their interrelations defined by a minimal functional description (concurrent engineering>;
- involving external engineering experts, subcontractors and/or services; and
- reacting to changes of the production environment.

From the viewpoint of production, flexibility means to be able to:

- build different kinds of products using the same or a changed production environment;
- cooperate within large varying consortia of subcontractors and suppliers;
- react to lack of capacities in different disciplines and departments;
- deal with non-pre-defined order flows (concurrent engineering);
- satisfy different customers' quality standards under economic constraints.

Production control must be handled on the basis of actual economic optimization criteria (e.g. costs,

due dates, consumption of man-hours) and external or internal unforeseen events like unavailability of resources, delayed sub-delivery dates, delayed due dates. The complex production scenario in shipbuilding with high probability of unforeseen events in every production phase must be flexible to react immediatly to actual control decisions. This capability must be based on detailed monitoring of the actual production progress as well as on the actual capacity load of resources. This has to be based also on descriptive functional and operational models of production processes and multi-order handling.

Modeling Requirements

The described features of complexity and flexibility, which provide both a global and a detailed understanding of the manufacturing systems behavior and controlling mechanisms, as of the product to be manufactured. With regard to the production and design management tasks the value of modeling instruments, techniques and approaches must be evaluated under the following aspects:

- Configuration or change of the production environment must be integrated with instruments that operate and control the production and design process.
- To be able to handle actual and unambiguous product information is a basic requirement for flexible process management and control, especially of the concurrent engineering process.
- The functionality of process elements (even the CIM elements) as well as the product requirements have to be understandable not only for the engineers or the production and design managers, but also from the perspective of the shopfloor workers.

This viewpoint has been the basis for the modeling approaches and exercises of the following examples. The implementation of CIM elements in the manufacturing environment, as well as the handling and control tasks of distributed multi-supplier organizations has to be conceptually supported and developed by the production and production management experts. Even the introduction of advanced services, based on enterprize internal knowledge about the complex products, has to be based on the involvement of the service providers as well as of the end users.

PRODUCT MODELING

The product model described below is the result of the ESPRIT project NEUTRABAS. The development of the Product Model SHIP is based on the product modeling methodology of the evolving IS0 Standard STEP. Information Model in this context means the description of the real world in a way which is independent from any implementation restrictions.

The NEUTRABAS Project did benefit much from the exchange of ideas and the cooperation with the NIDDESC project group. NIDDESC was initiated before NEUTRABAS and has contributed valuable documents to the IS0 STEP committee. (3), (4). NEUTRABAS has incorporated NIDDESC concepts and is working on complementary areas of the product life cycle.

Model Structure

The NEUTRABAS Product Model aims to cover the whole life cycle of a ship (10). For the time being two main models are defined to describe the "Object Ship:" the Ship Structural Model and the Ship Outfitting Information Model. Beside these there are the Ship Global Information Model and the Ship Spatial Arrangement Model. These Models have to be integrated and combined with the ship Reference Model.

Ship Global Information Model (SGIM):
SGIM contains information not only about the ships main dimensions, but also the information describing the performance of the ship such as speed, tank capacity, number of containers, etc.

Ship Spatial Arrangement Information Model (SSAIM):
SSAIM covers the information about the room arrangement, how surfaces and volumes define the subdivision of the ship. These subdevisions are: zones, compartments, major surfaces, their boundaries, contents and loads, and their related attributes.

Ship Structural Information Model (SSIM):
SSIM describes the information related to the design and production process of the ship steel structure. At the first level the shell plating associated with the major surfaces, including the partition into plates and its relation to internal

structures, are outlined. At the second level the stiffening and connection between elements, including standard shapes, their arrangement and connection with plates, are described. At the third level apertures and other inconstancies including those for man access, circulation of fluids and passage for duct-, pipe-, and cable-work are defined.

Ship C&fitting Information Model (SOIM):
SOIM defines everything within the steel envelope. Examples are machinery, cargo handling sytems, accommodation, and electronic equipment. To present all information about these different systems in a neutral way, the model must be independent of any specific enterprise's product structure and at the same time complete and general enough.

With the aim of an integrated model, the development of application driven partial models was started. The view on a ship and/or part of a ship changes over time. It starts with the viewpoint of the staff responsible for the contract, then passes to a shipbuilding engineer responsible for the design of that system, then to the production engineer, and so on, according to the procedures necessary to make an idea a product. The last view in this chain is the view of the owner who operates the ship and tries to earn money with it.

It is one of the main requirements for a product model to handle all these different views.

The Outfitting Functional Model (which is a part of the SOIM) serves as an example for the entire NEUTRABAS model. It contains the information necessary for the contract and functional design. It will be described later in more detail. Besides the mentioned NEUTRABAS models, STEP provides resource models such as geometry, topology, material, etc. One of the crucial tasks still to be performed is the integration of these different models. Within NEUTRABAS different integration strategies have been discussed. The most challanging one is shown in figure 4. The approach under consideration is the integration via one general model relating the partial and resource models in a flexible and open manner. This general model provides all information necessary to derive all key entities of the partial submodels via multiple inheritance. This approach is also used within the IMPPACT project (8).

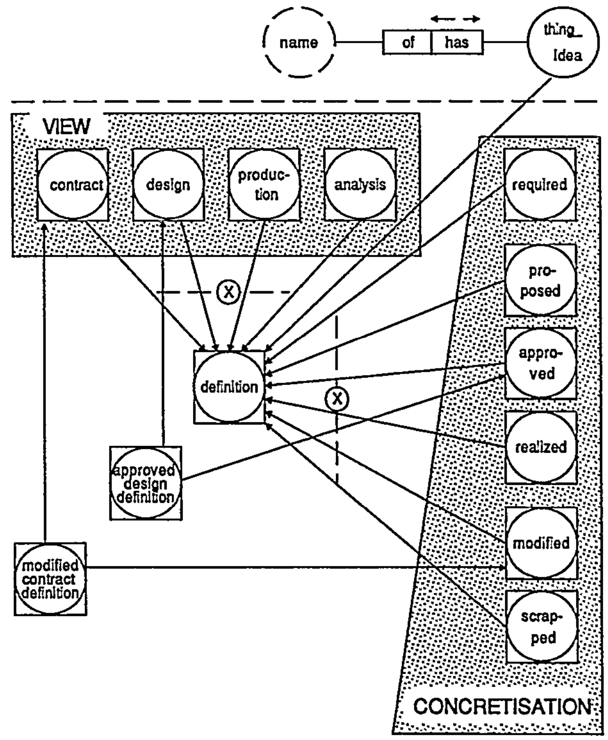


Figure 4: High Level Integrated Model

Modeling Methodology

The development of the model follows the STEP idea to provide a common mechanism for representing Product Model Information throughout the life cycle of a product, independent of any software that may be used to process it. "The definitions given within these models are independent of the many possible ways in which the related data might be implemented."(5)

Based on an entity pool and attribute list which arose from a questionnaire activity of the NEUTRABAS partners, a graphical method was used to illustrate the relationship of entities. Within the STEP community the use of IDEFlx and NIAM is common practice. NEUTRABAS decided to use NIAM because

1) its approach is more implementation independent than that of IDEFlx;
2) it is used by the NIDDESC group; and
3) of its readability even for those who are not familiar with semantic modeling. The point refers to the main benefit of the graphical representation and the illutration of entities and their relations as a basis for the discussion with "experts".

The author-reader cycle of modelers and experts, required some extensions of the NIAM to distinguish between relations which are approved or still under discussion. There are also NIAM extensions which take into account the complexity of the multifunctional model, in particular mechanisms to reference from an incomplete description to entity descriptions in other sub-models. In the discussion of modelers and experts the most crucial difficulty was in combining the generic approach of the model with the very precise and specialized understanding of the experts (figure 5). To overcome these problems “hand-made” population of a model with “real world” examples turned out to serve as helpful exercises.

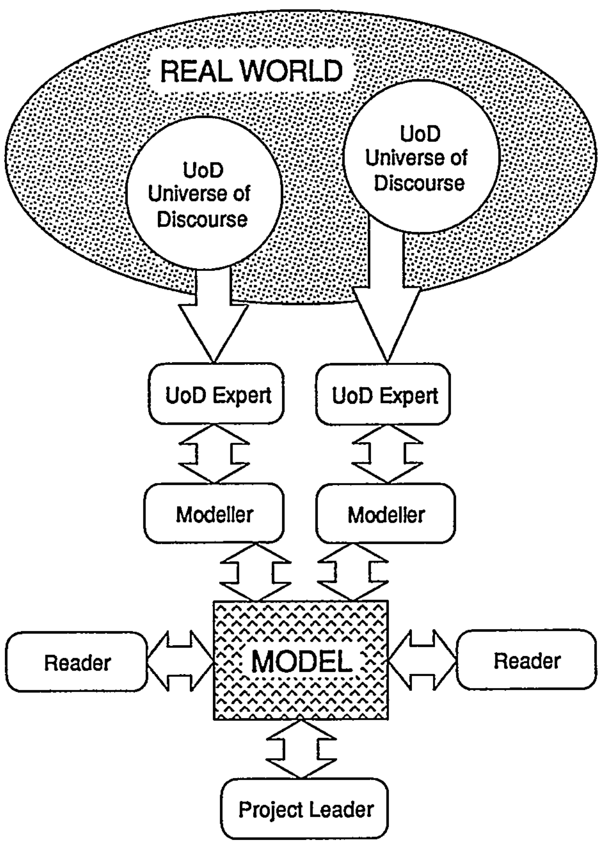


Figure 5:
From Expert Knowledge to an Information Model

The next step following the definition of the graphical model description is to derive a semantically irreducible definition of the model based on the NIAM diagrams with the help of a modeling language. Guidelines have been developed to streamline and standardize the process of mapping graphical model content into a (EXPRESS) language model. Figure 6 shows in selection some of these mapping rules from NIAM to EXPRESS (9). To handle this, first a pseudo code is to be created. The pseudo code contains the entity name, types and subtypes, their attributes, restrictions and rules, and of course, the definition in natural language.

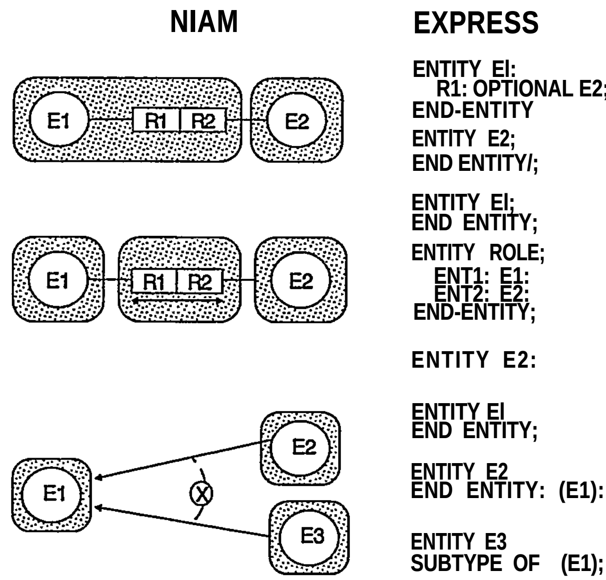


Figure 6: From NIAM to EXPRESS

Following this EXPRESS code is to be generated. EXPRESS is the information definition language designed for the requirements of information modeling within the context of STEP and is going to be standardized by ISO.

Due to the lack of sufficient tools the above-mentioned process is more or less hand-made, i.e. with the help of drafting tools, databases and word processors (figure 7).

EXPRESS then can be checked for its syntactical correctness using one of several available EXPRESS parsers (6). Most of them provide only syntactical check based on EXPRESS versions more or less behind the actual language definition. Within NEUTRABAS a data dictionary was developed to serve as a basis for different modules to handle the EXPRESS code and the information behind it to fulfil tasks like EXPRESS to SQL or EXPRESS to OoDB mapping, etc. The development of integrated tools to support the modeling process, considering the above mentioned problems and required capabilities as described above, is an ongoing process worldwide.

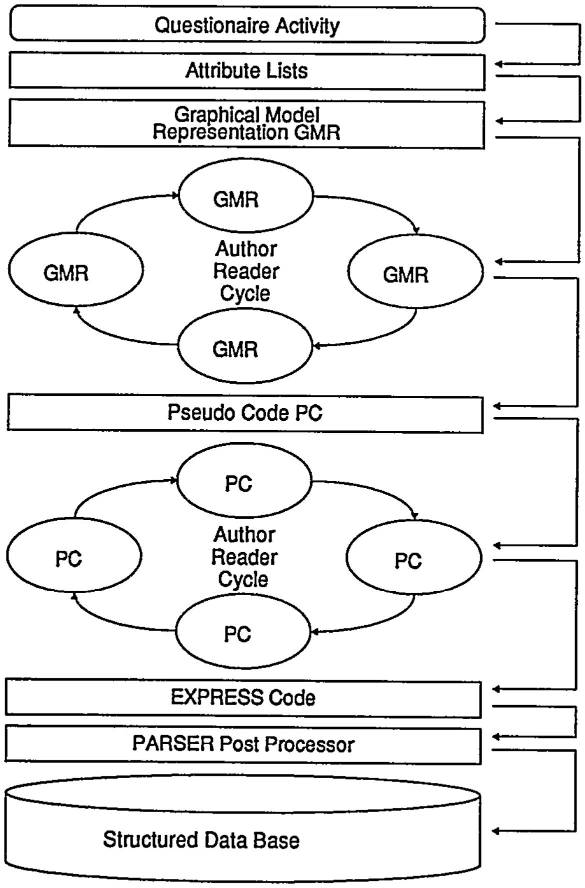


Figure 7: From UoD to Database

Functional Model

Within NEUTRABAS a new type of product modeling was worked out. It was named Functional Model and it deals with the description of what a product does or in other words what funtion it can perform. The necessity for such a model was obvious for documenting the creation of any system within a ship or within any other complex product. In spring 1991 a "Functional Model" working group was established in the STEP arena trying to handle this problem area.

During the design process, different designers are working on the same ship-outfitting system. Each of these designers is responsible for a certain functionality of the system. If the proposed results are conflicting, they have to be checked against the system requirements and a coordinated solution has to be found. This new solution must meet the requirements as well as perform the different functions of the system. To reflect this information in a product model is the purpose, the functional model is used for.

In reality each system plays different roles to satisfy different functions. One approach to handle the problem is well known as Taylorism but it will fail in this case. But the interoperability between the systems and their functions allows no isolated problem solving strategy. To handle the multifunctionality of a system which contains other multi-functional systems in one product model, an entirely integrated approach is needed. This may end with a redundant data structure which has to be controlled somehow. For example: a pump plays a role in the distribution system. It pumps a certain amount of fluid in a certain time interval up to a certain level. The same pump plays the role of a energy consumer in the electrical system as well as playing the role of an agent in a vibration calculation, and so on. It is conceivable that this pump could also play some more roles within the system "Ship" where it is installed. The NEUTRABAS outfitting model contains various functional systems e.g. distribution, containment, connection, control, fixing, heating, information, transformation, transportation, system.

The basic entity in the NEUTRABAS ship outfitting functional model is "system". It was chosen to describe the reason for the existence of each product within its environment. Thus a set of components joined to play a certain role together may be called a system. For the decomposition of a system into its components a recursive structure is used so that a system component can act as a system in its own right. This implies that one system or system component has different roles in different contexts, and/or different functions in different contexts. This is called multifunctionality.

This methodology serves as a basis for the definition of attributes required to carry out and accomplish the different engineering tasks. The calculations necessary for sizing of system can be associated with the systems components. Due to the associations of a system with its environment, the cross reference effects is obvious.

The modelers intention is to configure the model in such a way as to foresee the possibility of checking the model against rules and specifications. This should include requirement lists, owner specifications, classification rules and national regulations. For the time being the computer aided applications in these areas are still missing, or they exist only in a research environment. But it is expected that when such models exist, the usability of this information for testing and checking will increase immediately.

PROCESS MODELING

Process modeling discussed in this paper is the description of business activities in order to achieve specific technical or - more general - economical enterprize objectives. The formal components, rules and constructs to describe a problem oriented view on business activities as well as the information structure behind is the background of the process modelling exercise. The examplarily cases will describe process modeling as a supporting instrument for introducing computer technology in order to achieve technical or economical enterprize objectives. This regards on one hand the adaption of a shopfloor monitoring and control system within a shipyard outfitting environment and, on the other hand mobile satellite services as a communication platform for maintenance and repair support in ship operation. The one-of-a-kind characteristic of the product was the driving force for investigating in modeling applications in both R&D projects. The applied modeling methodologies and instruments are referred to in basic projects within the ESPRIT program.

A basic R&D investigation in the development of standardized architectural frameworks for computer application in industrial environments was established with the ESPRlT project CIM-OSA (ESPRIT 688: Computer Integrated Manufacturing - Open System Architecture). The CIM-OSA consortium AMICE defines its modeling objectives from the viewpoint of both the IT and applying industries. It formulates the objectives as, "to define a set of concepts and rules to facilitate the building," (planning, implementation, modification, extension and operating) of future CIM systems. A three-dimensional framework of architectural levels, modeling levels and views has been established to describe business processes (figure 8). "Generalized models are required to identify the principle components, processes, constraints and information sources to describe a manufacturing business processing towards CIM. The generalized models then need to be made specific by including aspects from particular manufacturing segmentations. Such a structured concept or architecture is called open system architecture (OSA)."(2)

A broad approach to define characterics of one-of-a-kind production is introduced in the FOF (Factory of the Future) project (Project Towards an Integrated Theory of Design, Production and Production Management of Complex One-of-a-Kind Products in the Factory of the Future). The "human

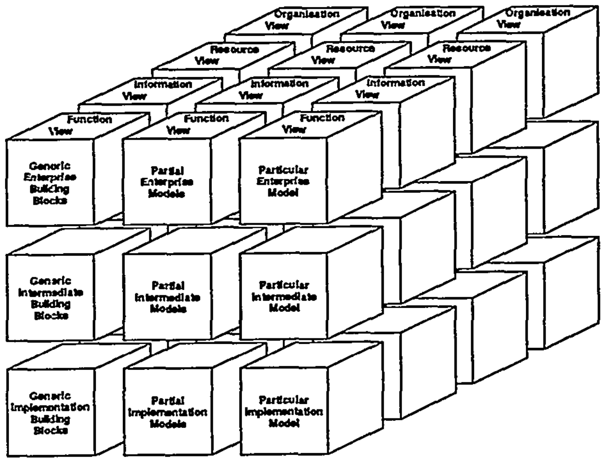


Figure 8: CIM OSA Modeling Framework

view" has been established as the basis of an additional integrative model This view has been introduced with the assessment "that the crucial point was, that (in general) the IT approach (the approach of introducing information technology) was focussed to enlarge the information and knowledge-base for managers. This improves the ability of control for the managers but still excludes the creativity, skills, involvement and engagement of the direct production workers." The breakdown of various aspects of one-of-a-kind production can be summarized according to the FOF project as

- operations research and cybernetics,
- human oriented,
- communication oriented,
- databases,
- functional,
- organizational, and
- economical.

The following described applications of modeling methodologies and techniques are referring to European R&D investigations in the field of CIM-implementation at shipyards and introduction of mobile communication applications for the maritime industry.

Implementation of CIM in One-of-a-Kind Production

The economic challenge to adopt modem technology to complex manufacturing processes demands the thorough knowledge of features, behavior and interrelations of process elements. The definition of requirements for the adaptation and implementation of CIM elements needs to be based on the problem

oriented description of the system environment in question.

The ROCOCO project (ESPRIT project 2436: Real time monitoring and control of construction site manufacturing) deals with implementing a shop-floor control solution into shipyard construction (7). The background description of the behavior and control mechanisms of outfitting processes has been worked out for an example shipyard. The developed reference architecture is general to other shipyards and - what is much more essential - also comparable to heavy engineering manufacturing systems. The reference model focusses on the implementation of a LSC (local shop computer) workstation into a pipe fitter's working environment. The LSC workstation is connected to a data capturing infrastructure as well as to the central engineering computer systems.

In order to reach a wide anticipation of the described modeling exercise, the main objectives of the ROCOCO modeling approach were:

- modularity;
- generality;
- extendability; and
- to be adequate for implementation,

which are in line with the CM-OSA objectives.

The ROCOCO project objectives require that the modeling approach must generate a generic reference architecture for different shopfloor applications. Similiar workshops at a shipyard (e.g. HVAC prefabrication) can - from the view of control behavior - be supported by the same conceptual LSC components. In general the PPC (production Planning and control) point of view has mainly influenced the selection of the modeling methodologies. The adopted GRAI and IDefO methods have been selected in order to follow the CIM-OSA objectives as far as possible.

The decision for using two different modeling methodologies was driven by the different characteristics of the two major implementation worlds. The phvsical production process (e.g. pipe prefabrication, staging, installation) contains the material tracking elements of the business processes. The complementary management world acts as the source for monitoring data and controlling events. Its functionality is characterized by the material flow, organization of work, machinery equipment and labor. Different work trades are similar, or more or less comparable in their controlling behavior within the business process. The production management process (e.g. design, stock

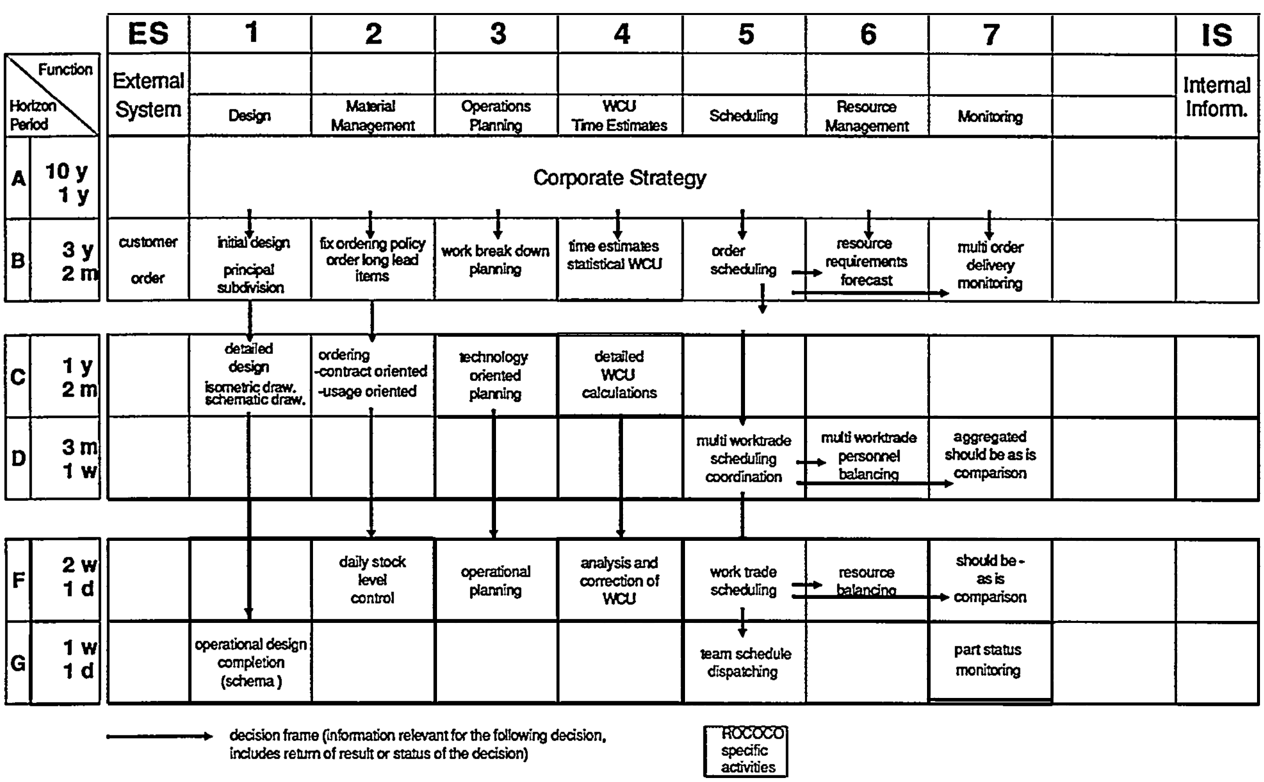


Figure 9: GRAI - Grid Activities

keeping, PPC) is characteried by the event driven mechanisms of decision making and information handling. A limited group of centralized enterprise functions has to specify, plan, trigger and control an extendable number of decentralized worktrades or shopfloor departments (figure 9). The GRAI methodology differenciates for every enterprise activity spezific strategical, tactical or operational levels. Those enterprise activities relevant for the LSC application are mainly allocated at the operational level; for interconnecting the relevant planning and scheduling tasks enterprise activities from the tactical level are involved. In order to get a controllable and effective management structure, different connected decentralized workshops have similiar interconnections and feedbacks to the central order management system.

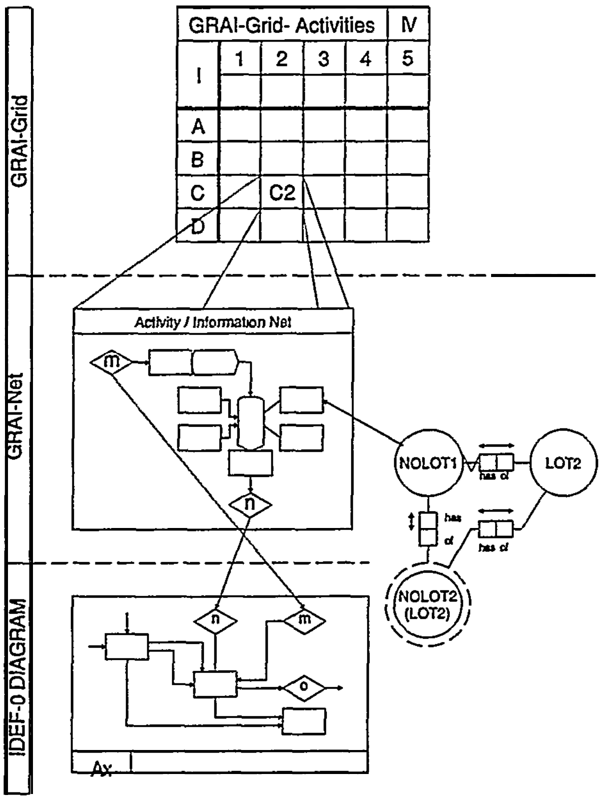


Figure 10: GRAI - IDEFO - NIAM Interconnection

In addition to the two-fold functional description of the business processes, NIAM as a data modeling language was used. The NIAM descriptions were methodically connected to the integrated GRAI and IDefO format of the process description (Figure 10). The connection and integration of the three adopted methodologies has to be used as an implementation guideline for the developed LSC application systems. The guideline has to be generic for different types of construction site manufacturing within the heavy engineering industrial sector. The integrated methodological approach has to end up in generic descriptive elements (generic building blocks) which, by following the CIM-OSA objectives, is a step towards the Generic Building Blocks within the CIM-OSA Modeling Framework (see also figure 8). The ROCOCO specific objective to adopt this integrated approach on a concrete level is to get a well defined specification of the controlling and controlled processes on the one hand, and of the applied CIM-solution on the other hand.

Communication Applications in Ship Operation

The advanced potential of IT.-applications is in the complex context of the extended enterprise logistics. Manufacturers, suppliers, distributors and operators are closely related to the product. In this context the economic importance of logistics and services based on worldwide communication infrastructure arises. The ability to provide consultancy, expertise and assistance to ships at sea is examined within the MARIN-ABC (RACE project 1062: Marine Industry Applications of Broadband Communication) project. This project demonstrates a pilot application of integrated NB/BB (narrowband/broadband) interconnection of shorebased and mobile - ship located - communication partners. It is assessed that competent support for maintenance and repair tasks, multi-media information services can solve the spontaneous challenges of economic ship operation. The integrated flexible use of video, audio, pictures and data (multi-media) provide most of “human comparable” communication features. The adequate implementation of end user equipment and services must ensure the most effective support of a spontaneous problem situation.

The modeling of the communication infrastructures in relation to the application services and end users’ activities (within their business environment) describes different communication scenarios. The modeling exercise specifies the value of communication applications from the viewpoint of:

- application functions within ship operation,
- specification of technical requirements,
- marketability assessment of mobile communication services,
- implementation strategies and cross-impacts of introducing mobile communciation to the european market, and

- scriptbook of an advertising application scenario to be realized within a video clip.

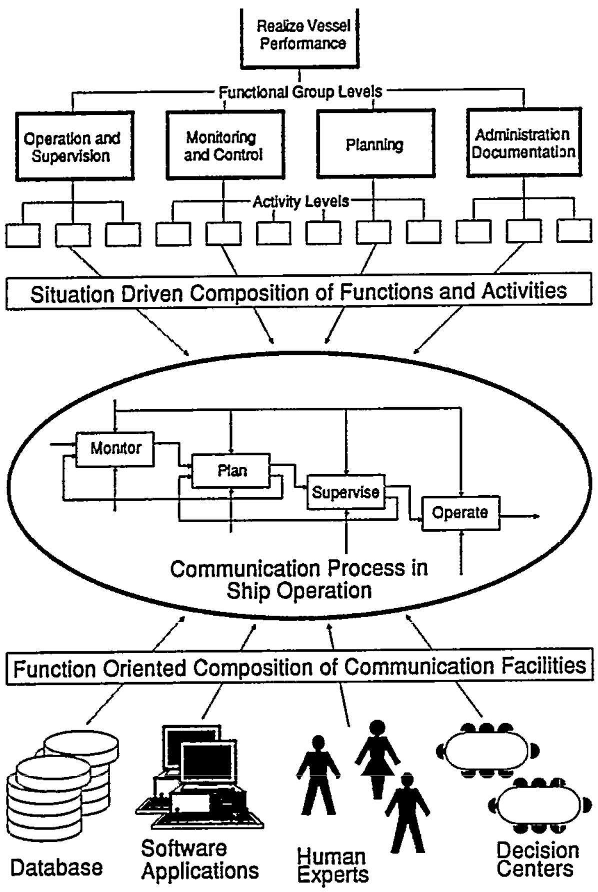


Figure 11: Function Oriented Composition of Communication Facilities

In accordance with the CIM-OSA approach, four essential views have been defined:

1) The object view decomposes the onboard functional and technical systems down to a significant level to handle maintenance and repair tasks.

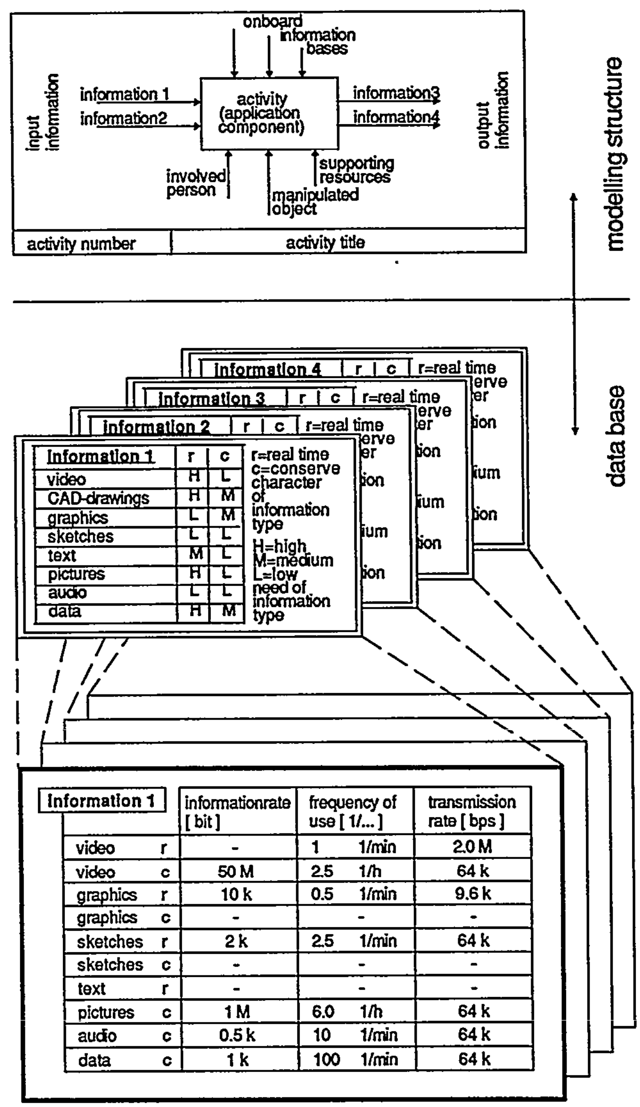
2) The functional view structures onboard and shorebased activities (application functions) related to maintenance and repair tasks, such as expert supervision, tutorial assistance.

3) The organization view describes the onboard and shorebased local allocation and distribution of responsibility of tasks, such as technical superintendency of a shipping company.

4) The resource view deals with the IT application and communication interfaces, networks and services which utilize the deverse tasks within ship operation on board, and the shore based consultancies.

The modeling exercise ends up in a reference architecture of user applications of integrated NB/BB communication in the field of ship operation (figure 11). Database implementation of an extension of the IdefO methodology leads to an estimation of quantified communication demands. Based on a specific application scenario described from the mentioned four views, transmission rates, frequency of use and transmitted information rates can be estimated (figure 12).

A techno-economic evaluation of these communication applications and network configuration from the view of the end users results in the providing of services and networks. This exercise of pre-com



Information 1	r	c
video	H	L
CAD-drawings	H	M
graphics	L	M
sketches	L	L
text	M	L
pictures	H	L
audio	L	L
data	H	M

Information 1		informationrate [bit]	frequency of use [1/...]		transmission rate [bps]
video	r	-	1	1/min	2.0 M
video	c	50 M	2.5	1/h	64 k
graphics	r	10 k	0.5	1/min	9.6 k
graphics	c	-		-	-
sketches	r	2 k	2.5	1/min	64 k
sketches	c	-		-	-
text	r	-		-	-
pictures	c	1 M	6.0	1/h	64 k
audio	c	0.5 k	10	1/min	64 k
data	c	1 k	100	1/min	64 k

Figure 12:
Database Enhancement of Communication Model

petitive assessment of marketability potential of mobile NB/BB communication in the context of the RACE programme opens the market for competent services of the maritime ship-building and operating industry. The challenge of especially the shipyards - in close cooperation with the shipping industry - is to provide additional services based on the deep knowledge, expertise, information about the complex multi functional products they build.

Modeling in the context of the MARIN-ABC project has the task to find, to describe and to evaluate useful applications for a technology (in this case the integrated NB/BB communication) which is planned to be available in the near future.

FUTURE OUTLOOK

In the far and near past in shipbuilding history, the overall manufacturing process developed mom towards scenarios of distributed competence, resources and performance. The shipyard itself is, in this scenario of distributed subcontracting and supplier cooperations, in the position of the central project manager.

The classical process chain ship manufacturing such as pre-design, design, operations planning, and starts from developing the first product idea and ends up with the rough job to fit and outfit the final product. The demands for heavy and expensive resources such as building docks, gantry cranes and steel hull fabrications facilities even today give the shipyard the position of the assembly and outfitting center for the complete ship. A complex distributed multi-supplier and multi-sub-contractor organization is grouped around the "central" shipyard. An increasing number of specialized tasks is distributed to these companies competent on their specific domain. The shipyard as the central project manager has the difficult and important task of planning and controlling such complex multi-partner cooperations. In future, shipowners, yards, classification societies, suppliers, and sub-contractors are active partners in ship manufacturing and ship operation. Powerful communication networks and applications are the technical background for the integrated maritime business of the future.

The challanging task for the future is, according to the referring European R&D programs, to realize the implementation of CIM to one-of-a-kind production. As a concrete representative of this kind of production the European shipbuilding industry has to focus on their capability to develop highly specialized and high quality products under manufacturing conditions which ensure economic and effective order processing. Mapping these main objectives on the capability of computer applications in general the economical trends of introducing CIM has to be seen in:

- increasing flexibility and effectivity of automated pre-fabrication;
- increasing effectivity of (especially outfitting) work by adequate planning and control instruments;
- exploiting the benfits of overall availability of product and production information;
- effective operation of complex distributed cooperations in manufacturing and concurrent engineering scenarios;
- providing competent services and logistics based on product life-cycle information.

Getting the competence and experience to handle complex distributed design and production systems is the key to exploiting synergy effects of CIM in distributed one-of-a-kind production. The complexity of those distributed manufacturing scenarios requires the adoption of the multi-view modeling approach in order to develop applicable CIM-concepts. The requirements for a supporting modeling approach towards implementation of CIM for these kinds of complex scenarios can be summarized by the keywords integration and distribution.

The integration of manufacturing applications with relevance for CIM has to be based on highest availability of product relevant information and highest performance of adequate product information exchange. The product modeling exercise, ending up in neutral standardized definitions for product defining data, has to consider the interests of maritime industrial users. Even the introduction of product modeling methodologies and techniques and the garantuee of a wide anticipation of modeling is of strategic relevance for CIM-implementation in shipbuilding.

The handling of distributed tasks, the managerial and organizational cross-impacts of companies interests and competence is based on communication between computer applications as well as between human users. Modeling the functional interconnections of tasks is the starting point for

planning, configuration and handling of distributed manufacturing cooperations supported by CIM-elements. The interconnections of tasks and the cross-impacts of goals and sub-goals needs to be modeled on an abstract level in order to ensure the most economic configuration for each project objectives.

Regarding the process chain of manufacturing, in the future the design and sustaining engineering work, as well as the modular pre-fabrication of machinery and outfitting components will be distributed more to subcontractors. In this regard, the distributed tasks have to be specified, planned and controlled based on additional descriptive modeling elements. The functional and managerial interconnections of distributed sub-contracted engineering activities must be organized. Technically it must be agreed upon information exchange and documentation formats, terms of responsibility and delivery. In general, the integration of the process chain of distributed manufacturing scenarios has to be supported by interfaces which consider both the technical requirements as well as the economic and organization objectives. The spezification and realization of these interconnections for the benefit of all partners in such cooperation must be strongly supported by both product and process modeling techniques.

Complex distributed cooperations lead to new requirements for the order chain of enterprise functions (acquisitions, tendering, cost-calculation and control, production planning and control). Shortest and reliable due dates, and most economical and effective achievement of manufacturing sub-goals directly requires the optimal operation of complex concurrent engineering scenarios. As the shipyard has to manage this scenario, the importance of multi-level planning and controlling techniques, with appropriate enhanced features arises. Modeling the behavior and mechanisms of changing order related cooperations is the starting point to realize and operate the future complex and distributed order processing.

Enhancing the described modeling exercises of the different CIM relevant projects in this paper, following open subjects have to be named:

- generic CIM element database and configuration support;
- flexible production environment configuration support according to product requirements;
- integrated techno-economic evaluation of CIM-systems;
- open inter- and intra-enterprise information exchange and communication; and
- open information infrastructure for plug-in applications.

The modeling methodologies and techniques to support on the one hand the distribution of work to complex consortia and on the other the integration of applications for different competent tasks need to be handled as an integrated set of instruments for planning, configurating and operating future CIM-production in shipbuilding. Realistic economic goals of concurrent engineering scenarios can not be reached without concentrating both on integration and distribution aspects of CIM in one-of-a-kind production. Therefore the deviating ways of following the product or process modelling approach has to be integrated to a future approach of product and process modelling.

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